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(54) DIGITAL MEMORY COIN SELECTOR METHOD AND APPARATUS

(71) We, MARS, INCORPORATED, of Westgate Park, 1651 Old Meadow Road, McLean, Virginia, United States of America, a corporation organised and existing under the laws of the State of Delaware, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

We hape invented an improved method and apparatus for coin selection utilizing a programmable memory, which can be simply and relatively inexpensively executed. At the present state of the art, this method and apparatus is most useful in a digital apparatus for coin selection. At least one digital method and apparatus for coin selection is already known as it was disclosed in Figure 8 and the associated text of U.K. Patent No. 1,397,083.

According to the present invention in one aspect there is provided a method of testing a coin for authenticity, including the steps of examining the coin and thereby producing an electrical signal having a value indicative of a characteristic of the coin, comparing the value with a reference value or values stored in a programmable memory to determine whether it corresponds to a value for an acceptable coin, and producing a signal indicative of the acceptability of the coin with respect to the characteristic if the value is an acceptable value, the reference value or values being fed into the programmable memory in a setting-up operation prior to examining the said coin, the setting-up operation including subjecting one or more reference coins to the same examination as the coin being tested and thereby producing an electrical signal or signals having a value indicative of the said characteristic for the reference coins, the said signal or signals being used to produce the reference value or values that are stored in the memory. The signal indicative of acceptability may also indicate the denomination of the coin as determined by that test. It is often desirable to conduct two or more examinations of different charcteristics of a coin and accept the coin only if all of the examinations indicate that the coin is a genuine coin of the same denomination; a matter which is discussed, for example, in the above-mentioned Application. Plural examinations are similarly desirable according to the method of the present invention.

The reference coin may be a specially manufactured coin replica or a coin which has been selected to produce a reference value signal for the examination being conducted. Thus, if using a set of such reference coins, the memory is loaded by recording the reference values for each of the coin denominations to be examined by the coin selection apparatus. The memory is then connected to permit comparison of the values produced by the examination of coins with the values stored in the loaded memory.

One type of information which may be advantageously stored in the memory as reference values is the limit values, such as maximum and minimum frequency from a variable frequency output coin examining station. Another variation of our method is to store only one reference value for each denomination and then apply appropriate tolerances to that value in conducting coin examinations.

In many methods of coin examination the characteristic being examined and the means of examination produce a varying output during the examination period. In such methods it is often only a positive or negative peak variance of the examination means output which is representative of the characteristic being examined. According to the preferred method of our invention, in such cases we employ the further step of determining the peak variance value, for example by periodically sampling the output of the examination means and selecting the peak variance value which occurs during the examination periods. This technique may be used both in the steps of loading the memory and of producing the value which is to be compared to the values in the memory in the steps of examining a coin. This method can be used,

for example, with the variable frequency output of an inductor sensing station such as the inductors in Figure 8 of U.K. Patent No. 1,397,083. It can also be used, for example, with the digitised analog output of other types of sensing stations, such as an inductance bridge or a phase shift sensing station.

According to the present invention in a second aspect there is provided an apparatus for testing coins for authenticity comprising means for examining a characteristic of a coin and producing an electrical signal having a value representative of the first characteristic, a programmable memory, means for comparing a value of the first signal with one or more reference values stored in the programmable memory, and producing a signal indicative of acceptability with respect to the characteristic if the value of the electrical signal is an acceptable value, and switching means defining two modes of operation of the apparatus, a setting-up mode in which one or more reference values corresponding to the value of the electrical signal are fed from the examining means to be stored in the programmable memory and a testing mode in which the value or values stored in the memory are fed to the comparing means to be compared with the value of the signal from the examining means.

In the drawings:

Figure 1 is a schematic block diagram of an embodiment of the invention;

Figure 2 is a schematic block diagram of another embodiment of the invention;

Figure 3 is a schematic block diagram of a digital peak picker which may be employed with the invention;

Figure 4 is a waveform diagram relating to the description of Figure 3;

Figure 5 is a schematic block diagram of another embodiment of the invention;

Figures 6A and 6B are waveform diagrams relating to the description of Figure 5; and

Figure 7 is a schematic block diagram of another apparatus embodying the invention;

The figures are intended to be representational and are not necessarily drawn to scale.

Throughout this Specification the term "coin" is intended to mean genuine coins, tokens, counterfeit coins, slugs, washers, and any other item which may be used by persons in an attempt to use coin-operated devices.

The apparatus 10 of one embodiment of our invention, shown schematically in Figure 1, includes a sensor 20 adjacent a coin holder or coin passageway 30, coin examining station circuitry 40 associated with the sensor 20 if such circuitry is used with the particular type of sensor, a programmable memory 50 and a comparator 60. The apparatus 10 also includes means for causing the sensed value to be compared with the value stored in the memory 50, such as examination control circuit 70 and switching means 80, and a memory loading switch 90.

The sensor 20, and the coin holder or coin passageway 30 are arranged with respect to the coin being tested according to known techniques, such as are described in the above-identified Specification. The apparatus is connected so that the value of a signal from the coin examining station circuit 40, if one is used, or from the sensor 20 itself, otherwise, is compared with a value stored in the memory 50 whenever a switching means, such as switching means 80, is activated to pass the one of the values to the comparison means 60. In this case switching means 80 is shown as controlling the flow of the sensor value to the comparison means 60. Alternatively, a switching means could be placed between the memory 50 and the comparator 60, or a switching means could be located in both inputs to the comparator 60. The switching means 80 is controlled by the examination control circuit 70 to ensure that the comparison is made at the appropriate time. The control circuit 70 may be activated by any of a number of means including a direct signal from the sensor 20, a signal from the coin examining station circuit 40 or from a separate coin presence sensor (not shown). One type of circuit which might be used is a peak picker, such as the ones described in connection with Figures 2 to 4 below.

In order to load the memory 50 or apparatus 10 in accordance with the invention, loading switch 90 is arranged to transfer the value from the sensor 20 or examining station circuit 40 into the memory 50 when the loading switch is activated to put the apparatus in a setting-up mode, for example by a signal on input lead 92.

Apparatus 10 can be implemented with digital hardware or with a combination of analog and digital hardware as is appropriate for the type of coin examination and sensors employed, and the accuracy required and available with current technology. At present, we prefer to implement the apparatus 10 with primarily digital hardware, converting the signal from any analog-output sensor which may be used, to a digital signal in the coin examining station circuit 40. Switching means 80 and 90 may then be AND gates or the equivalent, and the comparator 60 may be a digital comparator such as employed in the peak picker 301 described below.

If analog implementation is employed with a digital memory, the output of the memory 50 is converted to an analog signal, for example, by a converter which is part of the comparator 60. The comparator 60 includes conventional analog comparator circuits. The loading switch 90 or the com-

parator 60 would, in this case, also include an analog to digital converter.

The apparatus 210 of Figure 2 employs many elements similar to those of the apparatus 10 of Figure 1. The coin sensor 220, coin holder or passageway 230, the coin examining station 240, the memory 250 and the comparator 260 perform the same basic functions as the corresponding elements of the apparatus 10 of Figure 1. In the apparatus 210 of Figure 2, a peak picker 275 is used to select a value which is stored in the memory 250. When the memory 250 is being loaded, the loading switch 290 is activated by a signal on lead 292 to put the apparatus in a setting up node and cause the value at the output of the peak picker 275 to be loaded into the memory 250.

During the examination of coins, the switch 290 is deactivated putting the apparatus in a testing mode and the output of the peak picker 275 can be connected to the comparator 260 to compare that output with the contents of the memory 250. In the event that the output of the peak picker 275 produces a value between the limit values stored in the memory 250 for genuine coins of an acceptable denomination, the comparator 260 will produce a signal indicative of the tentative identification of the coin being tested as a coin of that denomination. Alternatively, a memory system which includes a maximum value identification system, such as the system of Figure 5 below, may be used during examination of coins and a separate peak picker such as peak picker 275 is not required at such times.

As in the case of the apparatus 10 of Figure 1, the apparatus 210 can be implemented with substantially all digital circuitry or with a combination of analog and digital circuitry.

Erasable and reprogrammable memory circuits, of the type used in the field reprogrammable metal - oxide - semiconductor (MOS) programmable read-out memory (PROM) circuits made by Intel Corporation of Santa Clara, California under its type numbers 1701 and 1702, are preferred for use as the memory in the method and apparatus of our invention. Such circuits have the advantage over fusible link PROM devices and the like in that the data entered into a reprogrammable PROM can be erased. In the case of the Intel units, erasure is by exposure of the circuit to an ultra-violet lamp. An error in entering data or a conversion of the machine to another set of coins can be readily corrected with reprogrammable PROM circuitry, whereas a non-reprogrammable device would have to be replaced.

A semiconductor random access memory (RAM), primarily comprising a group of flipflops, can also be used for the memory of our method and apparatus. Since the storage capability of a RAM is dependent on a constant supply of power, unlike the PROM type of memory, a dependable main or auxiliary power source such as a battery should always be connected to its power input terminals. To avoid excessive power drain from the battery, particularly during periods when the RAM is not connected to other sources of power, as is the case when the coin selector apparatus is in storage, the RAM should preferably be made with complementary symmetry metal - oxide - semiconductor (CMOS) storage elements. A pair of such storage elements is the Solitron type CM4013 dual flipflop. Other types of devices which might be employed are the so-called read-mostly memories (RMM) manufactured by Energy Conversion Devices of Troy, Michigan and the other types of RAM's on the market. Although specific types of standard model PROM and RAM devices have been mentioned to generally exemplify the technology which may be employed, custom-made medium scale or large scale integrated semiconductor devices may be preferable.

A digital peak picker 301 is shown in block schematic form in Figure 3. Its major elements include means for counting pulses during a period of precise duration, including a pulse generator 310 and a pulse counter 320; a register 340 containing a number representing the highest previous count; comparison means for comparing the count with the number stored in the register 340, including a comparator 350; and means for transferring numbers from the counter 320 to the register 340. To avoid a confusing proliferation of lines, Figure 3 shows only three stages of the counter 320 and a register 340, a portion of comparator 350 and the interconnecting leads for the stages shown; although various numbers of stages may be used and we contemplate the use in the present embodiment of approximately 10 stages.

The output of variable frequency source 370, such as an oscillator whose frequency is determined by the interaction of the field of an associated inductor with the coin being examined, is applied to one of the inputs of an AND gate 312. The other input of gate 312 is connected to the output of a precision duration pulse generator 310, which produces an output signal having a waveform such as the waveform 410 shown in Figure 4. The function of the gate 312 is to permit pulses from the source 370 to flow into the triggering input 322 of the counter 320 for a precise and repeatable period of time t_1—t_0, for example one millisecond. At time t_1, at the conclusion of the precise period t_1—t_0 the change in state of the output of pulse generator 310 turns off the flow of pulses from the source 370 through AND gate 312 to the counter 320. During the next period t_2—t_1 however, the output of pulse generator

310 enables AND gate 392 permitting three housekeeping pulses from clock 390 to flow to the pulse distributor 330. The pulse distributor 330, which may be made conventionally from flipflops, directs the first pulse to lead 331, the second to lead 332 and the third to lead 333.

The waveforms 431, 432 and 433, shown in Figure 4 are examples of the waveforms of the pulses on leads 331, 332 and 333 respectively.

A comparator 350 is arranged to compare the count in the counter 320 with the number stored in the register 340, which has been loaded with a number in the manner described below or may have been reset to zero or a standard initial value following the completion of a previous coin examination. If the count in the counter 320 is greater than the number stored in the register 340 at time t_1, the output of the comparator 350 produces a signal on lead 352.

When the first housekeeping pulse on lead 331 and the signal from the comparator on lead 352 are concurrently applied to AND gate 354, the output signal from gate 354 sets flipflop 356. If the count was less than the number stored in the register 340, the flipflop 356 would not be set.

When the second housekeeping pulse on lead 332 is applied to each of the group of AND gates 360 concurrently with a signal produced at the Q output of the flipflop 356 as a result of its having been set, the count in the counter 320 is transferred to the register 340 and stored in place of the number previously stored there. In the event that flipflop 356 is not set when the second housekeeping pulse occurs, as a result of the count being less than the number stored in the register 340, the count would not be transferred and the previously stored number will remain stored in the register.

When the third housekeeping pulse is produced on lead 333, it resets both counter 320 and flipflop 356, preparing them for another cycle of counting and comparing which begins at time t_2.

As an alternative to the digital peak picker 301 described above, an analog peak picker comprising, for example, means for charging a capacitor in a long time constant circuit, can be used to detect the peak value of analog signals in a combined digital-analog implementation of our invention.

Another embodiment of the apparatus of our invention is shown in Figure 5. This apparatus described and shown is intended primarily for a three denomination coin set, such as the U.S. 5-cent, 10-cent and 25-cent coins. The principles, however, are applicable to coin selectors for various numbers and types of coins. The arrangement and type of sensors is similar to that of Figure 12 of U.K. Patent No. 1,397,083. Located along a coin track 531 is a first pot core type sensing station 511, for example a high frequency (HF) inductive sensor, and further along the coin track there is a second inductive sensing station 512, such as a pair of inductors facing each other on opposite sides of the coin track 531 and connected to a low frequency (LF) sensing station circuit 522, such as a bridge circuit. Finally there is a third sensing station 514, in this case an "E" core inductor mounted above the second sensing station 512.

Coins are introduced into the apparatus through an input cup 520 that is arranged to capture coins inserted into the front panel of the vending machine. All coins take a common path through the apparatus and in doing so pass three sensing stations 511, 512 and 514. Each coin must satisfy test criteria applied at each of these three stations in proper sequence before it is deemed to be a valid coin. The first and third sensors 511 and 514 are connected in oscillator circuits 521 and 524 respectively. In normal operation the coin is present in the sensing field of 511 for some 65 milliseconds and in the field of 514 for some 40 milliseconds. During these time periods the presence of the coin causes the frequency of the associated oscillator 521 or 524 to shift from its normal quiescent idle frequency to another frequency characteristic of certain properties of the coin. Each of the two sensing stations 511 and 514 has associated with each coin denomination with which the apparatus is to be used, e.g. a 5-cent, 10-cent or 25-cent pipece, a prescribed bandwidth of allowable frequencies defining the examination results of that station for a valid coin. The frequency used to determine the validity of a coin is the maximum frequency to which the oscillator 521 or 524 shifts as a coin passes the associated sensor 511 or 514. If the maximum frequency shift does not fall in one of the allowable bandwidths as an object passes a sensor 511 or 514, then this object will be rejected by the apparatus.

Some sensing subsystems do not require the use of a memory. For example, sensor 512 and its LF sensor circuitry 552 generates pulses as coins or objects pass through its sensing field. The LF circuit 522 has an output for each acceptable coin denomination; one for a 5-cent piece, one for a 10-cent piece, and one for a 25-cent piece. A coin is designated as acceptable at the LF station 512 when there is one pulse only on one of the three outputs of LF circuit 522. This pulse should occur after the coin has been detected as having arrived at the first sensor 511, and before the coin has been detected as having departed from the third sensor 514. The presence of no pulses or more than one pulse on any one of the three outputs from the LF sensor circuitry 522 repre-

sents an invalid coin of that denomination. In other apparatus, a LF sensor system employing a memory can operate with the memory system in the same manner as a HF sensor station 511 or 514 operates with memory 550, comparator 560 and counter 580.

The frequency of the oscillators 521 and 524 are alternately measured by 10-bit counter 580. Precision pulse signals of approximately 1 millisecond duration, generated by a time pulse generator 540 at a frequency between approximately 14 and 56 kHz, are alternately applied to AND gates 531 and 534, to alternately gate the output of the oscillators 521 and 524 to the counter 580. During each such precision pulse period, a comparator 560 compares the content of the 10-bit counter with a count previously stored in a programmable read-only memory 550.

Stored in the memory 550 are a number of limit values, each at an addressable location. There is one set of such acceptable frequency limit values for oscillator 521 and another set for oscillators 524. Typical addresses for data relating to oscillators 521 and 524 are shown in Figures 6A and 6B, respectively along with typical limits for a three denomination coin set and the waveforms 6a and 6b for a typical 25-cent coin.

In each of Figures 6A and 6B, the shaded areas represent a band of acceptable frequency values for the outputs of oscillators 521 and 524 respectively. The first bit, 0 or 1 of each of the memory addresses shown at the left of Figure 6A and 6B, designate information pertaining to oscillators 521 and 524, respectively. The address information is provided to the memory 550 by the Q output of the time pulse generator 540. The last three bits of the address for the value which is to be read from the memory 550 is supplied by one of two three-bit counters or address registers 551 and 554, associated with the limit values stored for oscillators 521 and 524, respectively. During one of several short housekeeping periods between each precision pulse and the next, the number in each address register is set to 000 by a signal on lead 558 from the sequence and logic circuit 590, one of the functions of which is to produce housekeeping signals. Addresses 0000 and 1000 in the memory 550 each contain an arrival level value above the idling frequency of the respective oscillator 521 or 524, but below the lowest frequency value representative of an acceptable coin. Addresses 0111 and 1111 are not used, and are recognized by the system as addresses indicative of invalid objects. The periods t_a and t_b are the periods in which the presence of a coin is sensed at stations 511 and 514 respectively.

Taking for example the counting of pulses from the first oscillator 521, at the beginning of a count period the arrival level limit stored at address 0000 is supplied by the memory 550 to the comparator 560. When the count during the precision pulse period reaches and exceeds the frequency value stored at address 0000, the comparator 560 produces an output pulse which produces an input concurrent with the oscillator switching signal from the generator 540 at the input to AND gate 555 which then transmits a pulse to the address register 551, stepping its output to 001. The output of the address register 551 is directed to the memory 550 by AND gate 552 when a signal is received by the AND gate 552 from the Q output of the time pulse generator 540 and a timing signal from the generator 540. Whenever the count in the 10-bit counter 580 is detected by the comparator 560 to exceed the number stored in the addressed part of the memory 550, the appropriate address register 551 is advanced by one count to select the next address from the memory 550. The numbers stored in the memory 550 are the numbers corresponding to the lower and upper frequency band limits associated with each genuine coin of an acceptable denomination, i.e. a valid coin. Thus as the coin passes through the field of sensor 511, the frequency value produced by the oscillator 521 will rise through levels set in the memory 550 and the associated address register 551 will ultimately advance in count to an address corresponding to the frequency of the next limit level above the maximum frequency counted by the 10-bit counter 580. If this level is an upper limit of a frequency band associated with a valid coin, then the address stored in the address register at the conclusion of the precision pulse period indicated that the frequency rose to a level corresponding to a valid coin of the denomination for which the stored address is the upper limit. On the other hand, if the address is that of a lower limit for a valid coin, it indicates that the maximum frequency did not attain and pass that lower limit, and therefore the coin should be rejected.

The operation of the other address register 554, its activating AND gate 556 and its output AND gate 553, in conjunction with oscillator 524, is similar to that described for register 551, AND gate 555 and AND gate 552. A signal from the time pulse generator 540 during one of the housekeeping periods, after the address registers 551 and 554 have been reset by a signal from the sequence and value logic, causes AND gates 552 and 553 to return the addresses called for from the memory 550 to 0000 and 1000 before the next precision pulse period.

The sequence and value logic 590 receives timing signals from the time pulse generator 540, address information regarding the comparison in progress from address registers 551 and 554, the results of the comparison

from comparator 560 and the results of any other coin examinations, such as that from the outputs of LF circuit 512. This logic circuit 590 will produce signals indicative of acceptability and value of the coin being tested only if: satisfactory results are obtained on each of the examinations, each examination indicates that the coin is of the same denomination and the results of the examinations are received in a predetermined sequence. The sequence and logic circuit 590 also produces necessary housekeeping, such as the reset signal for the address registers 551 and 554, in conjunction with the time pulse generator 540.

Although the means and method of this embodiment specifically describe the sequential comparison of the information from a sensing station with information stored in the memory; information from the sensing station can also be compared simultaneously with information stored in the memory at several different addresses, representing values for a plurality of coins. The latter method is particularly useful when the lower limit value for one acceptable denomination is below the upper limit value for another acceptable denomination, creating an overlap in acceptable value bands.

It has been found that a practical improvement in coin discrimination can be achieved by comparing the information produced by an inductive sensor in the presence of the coin with the information produced by the sensor at a slightly earlier or later time when no coin is in the presence of the sensor. That method is described in U.K. Specification Application 1,443,934. The coin or other object to be tested is caused to pass along a known path past one or more poles of an inductor. A characteristic of the inductor output signal is examined in the absence of coins from the presence of the sensor and with a coin in the presence of the sensor, a function of these two examinations is produced (for example, the difference between the values produced in the two examinations) and then a signal indicative of the acceptability of the coin tested is produced as a result. These procedures tend to minimize errors resulting from shifts in value of the reference standards upon which the coin examination depends, such as oscillator idling frequency, the duration of pulse counting periods and the like. As a further development in this method, the coin is caused to pass between the inductor and a target of electrically conductive material on the other side of the path. The method and apparatus employing the step of passing the coin between the sensor and a target are particularly useful in minimizing errors caused by variations in the physical position of the sensor relative to the passageway, as in apparatus where the sensor is mounted on a moveable passageway sidewall.

Figure 7 illustrates an apparatus embodying the method discussed in the preceding paragraph. Coins are introduced into the mechanism 610 through an input cup 620 that is arranged to capture coins inserted into the front panel of vending machines. All coins take a common path along the coin track 631 through the mechanism and in doing so, pass four inductors comprising three sensing stations, 611, 612 and 613. Each coin must satisfy test criteria applied at each of these three stations in proper sequence before it is deemed to be a valid coin. Sensors 611 and 613 are connected in high frequency oscillator circuits, 621 and 623. In normal operation the coin is present in the sensing field of 611 for some 65 milliseconds and 613 for some 40 milliseconds. During these time periods, the presence of the coin causes the frequency of the oscillator to rise from its normal quiescent idle frequency to a higher frequency characteristic of certain properties of the coin. Each coin denomination, *i.e.* U.S. nickel, dime or quarter, has associated with it a prescribed bandwidth of allowable frequencies for each of the two sensing stations 611 and 613 which are used to define a valid coin. The frequency used to determine the validity of the coin is the maximum frequency shift of the associated oscillator during the presence of a coin. If this frequency shift does not fall in one of the allowable bandwidths, then the object will be rejected by the mechanism and not accepted as a valid coin.

Low frequency sensing station 612 comprises a pair of concentric inductors, one on each side of the coin track 631. Its associated discrete component circuitry 642, which may be of the type disclosed in the Specification of U.K. Patent No. 1,397,083 generates pulses as coins or objects pass through its sensing field. This circuitry 642 has three outputs: one for a nickel, one for a dime and one for a quarter. A valid coin in this station is recognized when one of the three outputs produces only a single pulse. This pulse should occur after the coin has been detected as arriving at the first sensor 611, and before the coin has been detected as departing from the last sensor 613. The presence of no pulses or more than one pulse on any one of the coin recognition lines from this discrete circuitry 622 represents an invalid coin of that denomination.

The frequencies of oscillators 621 and 623, associated with 611 and 613, respectively, are measured using a 10-bit counter. Each oscillator is alternatively gated via AND gates 631 and 633 and OR gate 635 into the counter 680 using a precise timing gate period of approximately 1 millisecond duration, generated by a stable reference timing oscil-

lator which is part of time pulse generator 640. The frequency of this reference oscillator is approximately 56 kilohertz.

Numbers corresponding to the idle frequency count of each sensor oscillator 621 and 623 are stored in the two registers 650 and 670, respectively. These reference values are stored when the housekeeping circuit 690 produces signals either approximately 300 milliseconds after power is first applied to the coin selector or approximately 300 milliseconds after an acceptable signal with respect to any denomination is received from a portion of the coin selector not dependent upon the reference value (*e.g.* a low frequency examination), followed by the absence of a coin accept signal (*i.e.*: a high frequency reject). The delay, which may be produced by the use of a counter within the housekeeping circuitry 690 to count pulses from the time pulse generator 640, assures a sharp, relatively noise-free pulse from the housekeeping circuitry 690 and, in the second case, assures that the coin leaves the system before the new reference value is entered. As a result, the reference value stored in registers 650 and 670 will not include values influenced by the presence of a coin in the vicinity of a sensor. By means of this periodic updating of the idle frequency reference values, small changes in the idle frequencies are tolerated without affecting the overall performance of the mechanism.

The content of each of the registers 650 and 670, and the counter 630 are periodically transmitted to an adder 684 by a multiplexer 682. The adder determines the difference between the number in the counter and the number in the appropriate register 650 or 670 for the oscillator 621 or 623 whose frequency is then being counted.

At the end of each 1 millisecond coin examination period, the output of the adder 684 is compared by comparator 660 with a number previously stored in the programmable memory 695. The address of the number read from the memory 695 to the comparator 660 is determined by one of two 3-bit address counters 651 and 653, one address counter 651 being associated with the sampling period for oscillator 621, the other address counter 653 being associated with the sampling period for oscillator 623. Whenever the output of adder 684 exceeds the number stored in this memory location, then the appropriate 3-bit address counter 651 or 653 is advanced by one count to the next address. The address from counters 651 or 653 is transmitted to the memory by multiplexer 656 and decoder 657.

The numbers stored in the memory 695 are the numbers corresponding to the lower and upper frequency difference levels associated with each valid coin. Thus, as the coin passes through the field of sensor 611, the frequency of the oscillator 621 will rise above the frequency produced in the absence of coins, the frequency difference count will rise through levels set in the memory 695, and the associated 3-bit address counter 651 will advance in count to an address corresponding to the frequency difference count of the next level above the maximum frequency difference which is produced. If this address represents an upper level of a frequency difference band associated with a valid coin, then it means that the maximum frequency difference was within an acceptance band, *i.e.* it is a valid address. If, however, this address corresponded to a lower level of a valid band, it means that the coin or slug caused the frequency to rise higher than that of a valid coin band, the address is indicative of an invalid object and that object should be ignored.

In order to detect coin presence and generate signals corresponding to the arrival and departure of coins in the sensor field, the output of the adder 684 is monitored at the end of each precision gate counting period. At this time, the address input to the memory is forced to 000 and the comparison made. The number stored in the 000 address in the memory corresponds to a small deviation from idle frequency and a deviation of the adder output to at least that value indicates the presence of a coin or object at the sensing station.

The determination whether a coin is valid is made when the system is in the recognition state and a coin has just departed from sensor 613. The housekeeping logic 690 produces a signal indicative of an authentic coin only if:

1. The 3-bit address counter 651 associated with the first sensor station 611 has a valid address in it for some denomination coin,

2. The 3-bit address counter 653 associated with the third sensor station 613 has a valid address in it for that same denomination coin, and

3. A single pulse has arrived from the circuitry 622 associated with sensor station 622 only for that same denomination coin.

The numbers stored in the memory 695 are characteristic both of the set of coin denominations the apparatus 610 is to accept and the dimensions of the apparatus 610 itself. The memory 695 is programmed using limit coin replicas as previously described.

WHAT WE CLAIM IS:—

1. A method of testing a coin for authenticity, including the steps of examining the coin and thereby producing an electrical signal having a value indicative of a characteristic of the coin, comparing the value with a reference value or values stored in a programmable memory to determine whether it corresponds to a value for an acceptable coin,

and producing a signal indicative of the acceptability of the coin with respect to the characteristic if the value is an acceptable value, the reference value or values being fed into the programmable memory in a setting-up operation prior to examining the said coin, the setting-up operation including subjecting one or more reference coins to the same examination as the coin being tested and thereby producing an electrical signal or signals having a value indicative of the said characteristic for the reference coins, the said signal or signals being used to produce the reference value or values that are stored in the memory.

2. A method according to Claim 1 in which a single reference value is stored in the memory for each acceptable denomination of coin and the setting-up operation includes subjecting one reference coin of each denomination to the examination and storing the value of the electrical signal in the memory as the reference value for that coin, the value of the signal for the coin under test being compared with the reference value for each denomination of coin and the acceptability indicating signal being produced if the value is within a predetermined tolerance of the reference value for an acceptable coin.

3. A method according to Claim 1 in which two reference values are stored in the memory for each acceptable denomination of coin, the reference values being representative of the upper and lower limit values of the signal for acceptable coins of that denomination, the value of the signal for the coin being tested being compared with the two reference values for each coin and the acceptability indicating signal being produced if the value is between the reference values for an acceptable denomination of coin.

4. A method according to Claim 3 in which the reference values are fed to the memory by subjecting two reference coins of each denomination, representative of the upper and lower values of the characteristic, to the examination, and storing the values of the signal for each reference coin in the memory.

5. A method according to any of Claims 1 to 4 wherein the coin is examined by subjecting it to an electromagnetic field, the value of the electrical signal is indicative of the interaction of the coin with the field.

6. A method according to Claim 5 wherein the interaction is indicated by the frequency of an oscillator which is a part of the means generating the electromagnetic field.

7. A method according to Claim 6 wherein the frequency is determined by pulse counting for a finite, brief period to produce the values which are compared with values stored in the programmable memory.

8. A method according to any of Claims 1 to 7 further including the step of producing a signal indicative of the denomination of the coin if it is found to be acceptable.

9. A method according to any of Claims 1 to 8 further including the steps of examining the coin and thereby producing a second electrical signal having a value indicative of a second characteristic of the coin, comparing the value of the second signal with a second reference value or set of reference values in the programmable memory, to determine whether it corresponds to the value of an acceptable coin, and producing a signal indicative of the acceptability of the coin with respect to the second characteristic when the value of the second signal is acceptable, the second reference value or set of reference values being fed into the programmable memory in a setting-up operation prior to examining the said coin, the setting-up operation including subjecting one or more reference coins to the same examination as the coin being tested and thereby producing an electrical signal or signals having a value indicative of the said second characteristic for the reference coins, the said signal or signals being used to produce the reference value or values that are stored in the memory.

10. A method according to Claim 5 to Claim 9 in which two reference values of the second signal are stored in the memory for each acceptable denomination of coin, the reference values being representative of the upper and lower limit values of the second signal for acceptable coins of that denomination, the value of the second signal for the coin being tested being compared with the two reference values for each coin and the acceptability indicating signal for the second characteristic being produced if the value is between the reference values for an acceptable denomination of coin.

11. A method according to Claim 10 in which the reference values for the second signal are fed to the memory by subjecting two reference coins of each denomination, representative of the upper and lower values of the second characteristic, to the examination, and storing the values of the signal for each reference coin in the memory.

12. A method according to any of Claims 9, 10 or 11 wherein the examination with respect to the first characteristic is dependent upon the interaction of the coin with a relatively high frequency field and the examination of the second characteristic of the coin is dependent upon the interaction of the coin with a substantially lower frequency field.

13. A method according to any of Claims 1 to 12 in which the coin is caused to move through to a position at which it is examined, and in which the production of the acceptability indicative signal with respect to the first characteristic is dependent upon whether

the peak variance of the first value corresponds to an acceptable value.

14. A method according to any of Claims 1 to 13 in which the electrical signal is an analog form at a coin examining station and the value of that electrical signal is converted to digital form prior to comparison with the values stored in the programmable memory.

15. An apparatus for testing coins for authenticity comprising means for examining a characteristic of a coin and producing an electrical signal having a value representative of the first characteristic, a programmable memory, means for comparing a value of the first signal with one or more reference values stored in the programmable memory, and producing a signal indicative of acceptability with respect to the characteristic if the value of the electrical signal is an acceptable value, and switching means defining two modes of operation of the apparatus, a setting-up mode in which one or more reference values corresponding to the value of the electrical signal are fed from the examining means to be stored in the programmable memory and a testing mode in which the value or values stored in the memory are fed to the comparing means to be compared with the value of the signal from the examining means.

16. An apparatus according to Claim 15 in which the programmable memory stores a single reference value for each acceptable denomination of coin and the comparing means produce the acceptability indicating signal if the value of the electrical signal is within a predetermined tolerance of a reference value.

17. An apparatus according to Claim 15 wherein the reference values stored in the programmable memory include the upper and lower limit values for coins of each acceptable denomination and the comparing means produce the acceptability indicating signal if the value of the electrical signal is between the upper and lower limit values for a coin of an acceptable denomination.

18. An apparatus according to any of Claims 15 to 17 including a coin passageway and means for producing an electromagnetic field in a region of the passageway, wherein the first value is indicative of the degree of interaction of coins with the field.

19. An apparatus according to Claim 18 wherein the field producing means includes an oscillator and the first value is dependent on the oscillator's frequency.

20. An apparatus according to any of Claims 15 to 19 further comprising means for indicating the denomination of acceptable coins.

21. An apparatus according to any of Claims 15 to 20 further comprising means for examining a second characteristic of the coin and producing a second electrical signal having a value representative of the second characteristic, means for comparing a second value of the second signal with one or more values stored in the programmable memory, and means for producing a signal indicative of acceptability of the coin only if the comparisons of the first value and of the second value both indicate that the respective values correspond to acceptable values for a coin of a given denomination.

22. An apparatus according to any of Claims 15 to 21 wherein the acceptability of the coin with respect to the first characteristic is dependent upon whether the peak variance of the first value is an acceptable value.

23. An apparatus according to Claim 15 or 22 further comprising a coin passageway, means comprising an oscillator and an inductor for generating a relatively low frequency electromagnetic field in a region of the passageway, means comprising an oscillator and an inductor for generating a substantially higher frequency electromagnetic field in a region of the passageway, wherein the value of the first electrical signal is dependent upon the frequency of the oscillator of the higher frequency field producing means.

24. An apparatus according to any of Claims 15 to 23 further comprising analog to digital signal converting means connected to receive an analog signal from an examining means and transmit a digital signal to a comparison means.

25. An apparatus according to any of Claims 15 to 24 including peak value identification means connected to receive and identify the peak value of the first electrical signal.

26. An apparatus according to Claim 25 wherein the peak value identification means is also connected to transmit peak values to selected locations in the programmable memory.

27. An apparatus according to any of Claims 15 to 26 wherein the programmable memory is an eraseable read only memory.

28. An apparatus according to Claim 19 or 23 further comprising a pulse counter connected to receive the first signal and a timing means arranged to activate the pulse counter for precise, brief periods of time.

29. An apparatus according to Claim 28 wherein the pulse counter is alternately connected to receive the first signal and a second signal.

30. An apparatus according to Claim 28 further comprising means for comparing the value stored in the pulse counter at the end of a period of time with at least one value stored in the programmable memory.

31. An apparatus according to Claim 28 wherein the value in the pulse counter is compared during the period of counting with values stored in the programmable memory.

32. An apparatus according to any of

Claims 15 to 29 wherein a plurality of limit reference values are stored at various addresses in the programmable memory, further comprising an address register arranged so that its output selects the address in the programmable memory which is connected to the comparison means, and the output of the comparison means transmits a signal to the address register which changes the address register output whenever a value received by the comparison means from the first characteristic examining means is at least as large as the value in the address of the programmable memory to which the comparison means is connected.

33. A method of examining coins substantially as described hereinbefore with reference to the accompanying drawings.

34. Apparatus for examining coins substantially as described hereinbefore with reference to the accompanying drawings.

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1452740 COMPLETE SPECIFICATION

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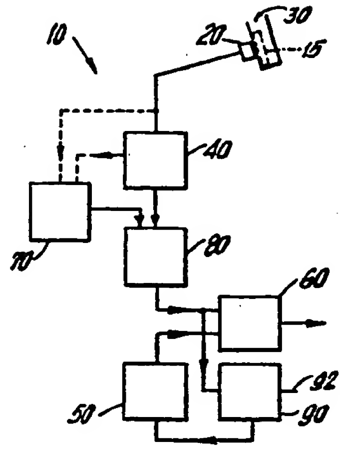

FIG.1

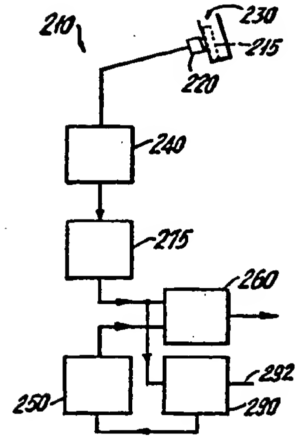

FIG.2

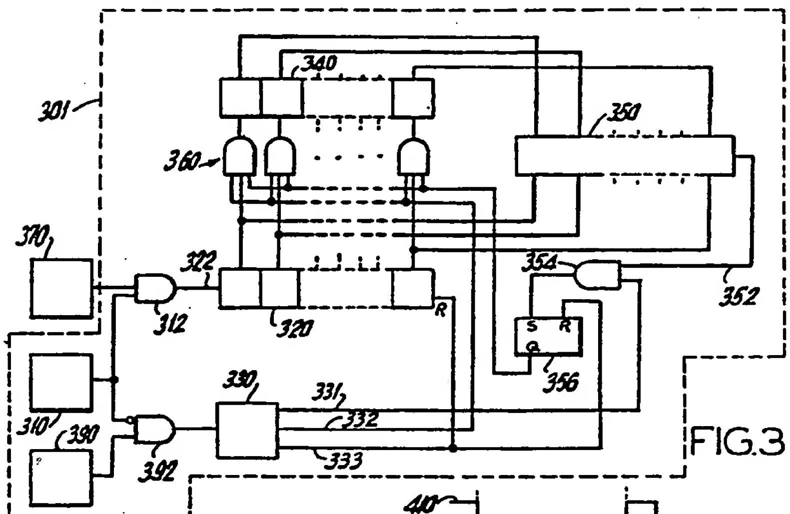

FIG.3

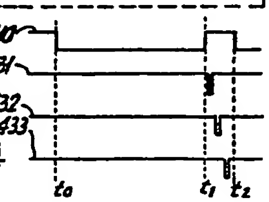

FIG.4

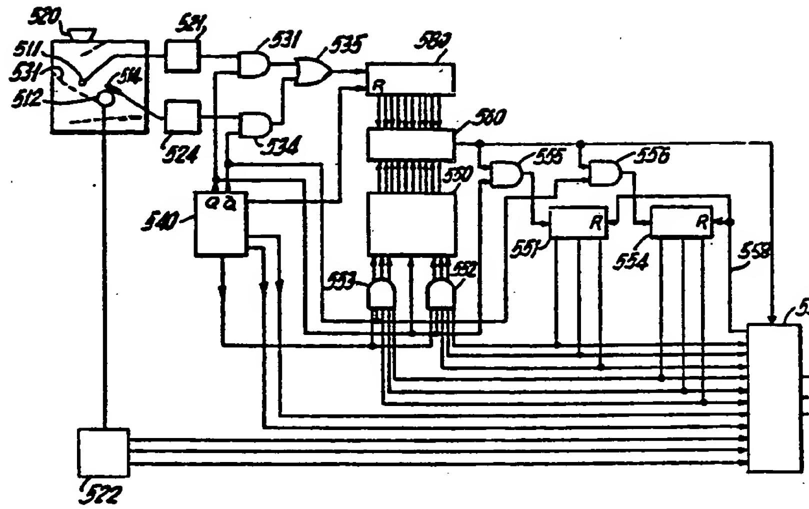

FIG. 5

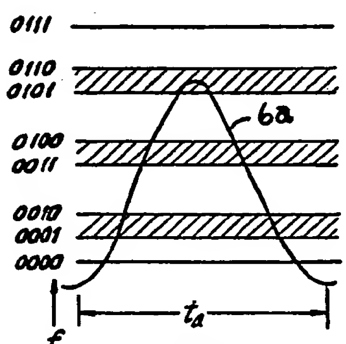

FIG. 6A

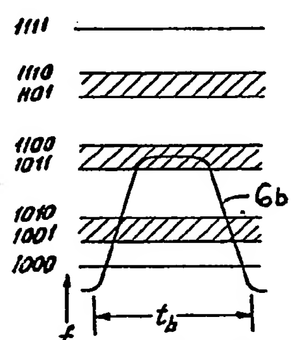

FIG. 6B

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